SUBNIVIAN WINTER ACTIVITY IN TERRESTRIAL INVERTEBRATES

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Translated from Swedish by C. W. Aitchison (corrected by O. Saether)

This paper discusses some general aspects of the activity of invertebrate animals during the winter and then gives the results of one study group on this question, a study which was carried out under a licentiate course (Ph.D. equivalent) in ecology, during the semester of 1963 at the Zoological Institute of Stockholm.

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ABSTRACT

During the cold season a very small minority of our insects are visible, which at first glance gives the impression that all insects have entirely died out. Closely observed afterwards, we shall find however a whole group of insects in different developmental stages. On dry land, in protected areas we can find eggs and pupae of different species - there they overwinter and there they hatch when spring arrives - or larvae and fully-formed (ones), which lie inactive in their dry, protected overwintering areas, until spring heat wakens them. Other kinds are not dependent upon any protection from the cold. To this latter group belongs the lemon butterfly, which spends the winter hanging in some shrubs, and also certain kinds of mosquitoes (Anopheles), which can endure temperatures of -40°C without injury.

Others again not only have the ability to endure cold, but even show activity at low temperatures. Such a winteractive insect is the snow scorpion fly (Boreus), belonging to the order Mecoptera (about 4 mm long, dark brown with stunted wings and long legs and antennae). The first fully-formed adults appear in September. Copulation takes place during the winter months, and eggs are laid in March. The newly-hatched larvae first appear at the beginning of April, after which the larval development (takes) 1½ years. During this period larvae live dug down in moss, which also makes up their food. First in August-September the succeeding year they pupate and, about one month later, the fully-formed individuals hatch.

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By experiments it has been shown that larvae and adults prefer different temperatures. While full-grown individuals of Boreus hiemalis look for temperatures about +10°C, larvae survive about +33°C, a temperature at which the adults cannot live even for a short time. If the temperature on the other hand is too low (-3 to -5°C), a cold stiffness appears. If the temperature is further reduced, the animals die, most of them succumbing after only a few minutes (Strübing 1958). These temperature experiments are consistent with the temperature relations in the biotopes, where larvae and adults respectively are active. The larvae appear exclusively during the warm season and on sun-exposed areas, where the temperature in the ground is about +35°C. The adults, on the contrary, are only found during winter and then on snow surfaces in favourable weather - otherwise down in the moss layer under the snow.

Isotoma saltans, also call the "glacier flea", shows considerably adaptation to activity in the cold. This species, one among a few winteractive springtails (order Collembola), lives on glaciers and can be found there in unheard-of multitudes. Experiments show that they prefer temperatures between +5°C and -5°C, and that they can tolerate low temperatures down to -8°C for several hours. They can even survive -19°C for one hour. On the contrary their power of resistance to high temperatures is not great; at +15°C the insect dies (Strübing 1958).

Among other now know winteractive insects, we can mention a wingless crane fly (Chionea), partheogeneic females of the oakgall hymenopteran (Biorrhiza pallida), a fly (Helomyza), and the frost butterfly. The latter hatch in September-November after the first frost nights. Following copulation the wingless females seek out leaf buds, laying eggs there to

overwinter, and die. At least one sex of all known species is totally void of wings or have reduced wings. The importance of this fact is still not being investigated.

In the beginning of the 30's a simple and very effective method for capturing small, ground-living invertebrates was introduced (Barber, 1931). The trap consists of a glass jar (diameter 20 cm, height 40 cm), dug into the ground and placed with the opening level with the soil surface. The jar was filled 1/3 full with a preserving medium, which swiftly killed and preserved the animals which fell down. A few centimeters over the jar was placed a wire mesh or a disc to prevent earth, leaves, and rubbish from falling down inside. An advantage with this trap is that it can stay out for a long period - in one of Barber's experiments up to 6 months.

Such "Barber Traps" have been used in Germany for studies of the invertebrate fauna, (Heydemann 1956, Renken 1956). These scientists let the traps stand out for a full year and emptied them at equal intervals. The method gave valuable information about where and when developmental stages of different species appeared. During the winter trap captures were dominated by rove beetles (fam. Staphylinidae) and flies (ord. Diptera). They also contained larvae of Coleoptera, such as blister beetles (Cantharidae), rove beetles, and ground beetles (Carabidae).

In certain areas individual densities of prey-living beetles (e.g., rove and ground beetles) are very high during the warm months, while in winter they are especially low. During this period, when for example competition for scarce food and the risk of falling victim to predators is considerably less than during the remaining part of the year, the winteractive animals have an increased chance of survival.

The activity of the previously mentioned animals has been limited to the snow surface or to bare spots in the snow cover, where the climatic conditions still are extreme. However, favourable climatic conditions for winter activity exist in the space between the snow cover and the ground surface (the subnivian space). That is probably the prototype in areas where the snow, prevented by a rich layer of vegetation, does not reach the ground.

Investigation Results

During the winter of 1963, an investigation of subnivian activity in terrestrial invertebrates was carried out with the help of modified "Barber Traps". The investigation took place from the 28th of January to the 8th of April, and was performed by a group from the Zoological Institute at the University of Stockholm. The work was conducted by C. C. Coulianos, Fil. Lic. (Licentiate of Philosphy). Besides the author of the article, taking part were B. Janning, K. Nordensjö, S. Södergren, and L. Österdahl.

Furutorp on northern Lidingö, about 10 kilometers north of Stockholm, was chosen as the area of investigation. Traps were placed within 3 different biotopes: a grass-grown field, an edge of a wood (mostly consisting of birch and alder), and a wooded area consisting of oak and pine trees. In all 41 traps were used, of which 16 were placed around the field, 15 in the edge of the wood, and 10 in the wood. The snow cover thickness during the cold period was about 30 cm.

We used modified "Barber Traps", consisting of 2 parts; one inner, replaceable jar and an outer plastic jar, dug down so that its opening was itself in the subnivian space and on the level with the ground surface. The inner jar was

filled 1/3 full with 4% formalin. In order to reduce surface tension in the preserving medium, a few drops of wetting solution were added. When the trap was examined, there was a risk of the snow falling down into the subnivian space and blocking the opening. In order to prevent this, the traps were protected with a masonite disc placed under the snow cover, a few centimeters above the ground level. Directly above the opening of the jar a hole was made (and was) covered by a lid (figure 1).

The number of animals in trap captures is an expression of the activity frequency. This constitutes a product of activity (in this particular example the horizontal movement activity) and abundance, (i.e., number of animals per unit area). The following formula is consequently valid:

$$\text{Activity} = \frac{\text{activity frequency}}{\text{abundance}}$$

The investigation was aimed primarily at exploring the subnivian fauna and its activity. Preceeding the investigations of activity, the abundance had to be determined, which took place by analysis of collected field samples (that contained not only the active portion of the fauna, but also the inactive). Since the field samples contained a lot of snow and ice, their volume or area could not be determined, which made a quantitative comparison between the different samples impossible. On the other hand they gave valuable information about the species distribution within the different samples.

The activity of subnivian animals can be influenced by climatic factors such as light, temperature, and humidity. The light factor is not subject

for study in this investigation. However it is known that solar radiation and diffuse radiation of the sky are able to partly penetrate the snow cover, and that these radiations are absorbed to varying degrees by different (types of) packed snow. If the radiation on the snow surface is assumed to be 100%, only 5-10% remains under a 30 cm thick snow cover (Geiger 1950). The relative atmospheric humidity (%R.H.) is very high (90-98% R.H.) in the subnivian atmospheric space, according to Geiger. Ecological meanings of light and humidity for the subnivian fauna will be studied more closely in future investigations.

Measurements of temperature were made with a 6-point temperature writer of a platinum resistance thermometer during two periods of comparatively cool weather the 28th to 30th of January, and partly during a warm period the 5th to 7th of March. Measurements were taken at a 150 cm height above the ground level (meteorological temperature), and at different levels within and under the 30 to 32 cm thick snow cover. Besides our own measurements of meteorological temperature, we used information from the meteorological station at Roskar on Bogesundslandet (SMHI).

From Table 1 the difference in amplitude between meteorological temperatures and that of subnivian atmospheric temperatures is evident (see also Coulianos and Johnels 1962). Consequently the subnivian atmospheric temperature is not directly affected by the meteorological temperature.

During the 10 weeks when the investigation took place, we caught no less than 3338 invertebrates. Of these more than half (1722) was taken in the field, and about 1/2 (1290) in the edge of the wood (see Table 2). In Figure 2 weekly catches clarify the distribution in the three different biotopes. The differences in the catch sizes have been important - not only between the different biotopes,

but also between traps within the same biotope (see Table 2). However, there are catches in each individual trap showing a tendency for a fairly constant number being maintained in proportion to the remaining traps throughout the whole period.

Comparison between different weekly catches (figure 2) shows that the week of 18th to 25th of February had the lowest value in the meadow, in the wood as well as at the edge of the wood, and also that a clear increase of catch occurred during the last two weeks. This increase began a week earlier in the edge of the wood than in the other biotopes.

Very low meteorological temperatures dominated during the week of the 18th to 25th of February. After that an increase in temperature took place, during which the traps gradually melted out. This thawing began earliest in the wood (already during the week of the 4th to 11th of March), and then proceeded very swiftly.

The winter activity of terrestrial invertebrates was investigated and mentioned in the literature to a low extent, for which reason some of the animals that were captured were not known earlier as winteractive (e.g, earthworms. and woodlice).

Table 3 accounts for the captured animals. Only the Coleopterans were determined to species, which was done by T. Palm, Dr. Phil.. The remaining animals are only classified to the larger groups of the previously known, winteractive invertebrates we have found the subsequent ones showing subnivian activity: larvae of blister beetles (Cantharis sp.), a majority of species of rove beetles (Staphylinidae), and a wingless crane fly (Chionea). It was

previously known that a few species of springtails and certain spiders show activity during the winter. The species that we found of these groups, however, have not been determined to species.

The entirely dominant animal group in traps were the springtails. They made up almost half of the total catch, or 1244 individuals (table 3). Three types of springtails were found to be very abundant, all belonging to Entomobryidae. The most common type was Isotominae, which made up 3/4 of all found springtails and were most abundant in the field, while the two remaining Entomobryidae (Lepidocyrtinae and Lomocerinae) were mostly caught in the edge of the wood.

The next largest group in the catches was the Coleopterans, within which rove beetles predominated. The most common among these were larvae of Lathrimaeum atrocephalum, of which a total of 787 individuals were captured, mostly in the field. This species did not show any obvious increase towards the close of the investigation period. On the other hand, such an increase was found in Olophrum piceum which was found only in the edge of the wood, and there only as adult. In that area also beetle larvae and spiders had their greatest distribution.

In order to calculate activity in an animal, one must, as mentioned previously, know its activity frequency and its abundance. An animal, which shows a high activity frequency (high number of catch), can either be very active in such a way that it is often caught and simultaneously be found in small numbers (low abundance , or also be very common (high abundance) but characterized by low activity. An example of this is constituted partly by Lathrimaeum atrocephalum (table 3), of which 787 specimens were taken during the whole investigation, and partly by mites, of which only 79 specimens were

captured during the same period. Lathrimaeum hence showed about a tenfold greater activity frequency than the mites. In the field samples, however, only five Lathrimaeum were found, but no less than about 2380 mites. In spite of certain errors with the sampling method, a comparison can be allowed since the differences in numbers are so great. Activity frequency divided by abundance gave an activity for Lathrimaeum exceeding values of 100, while that for the mites only constituted some one-hundredths. The difference in activity movements between these two is consequenlty much greater than divergency in activity frequencies.

A difficulty concerning the determination of activity is that there exist other types of activity, such as eating, copulation, or vertical movements, which do not lead to capture in traps. A species showing low capture numbers, or lacking in the traps, thus is not necessarily inactive in a particular case. The evaluation of such problems is made more difficult by the lack of knowledge of the biology of subnivian species.

It has already been pointed out that the subnivian space is characterised by very stabilised climatic conditions. Temperatures under the snow are constant about ± 0°C, even where meteorological temperatures vary drastically (shown in measurements performed by Coulianos and Johnels 1962). In addition, temperature measurements at Furutorp the 28th to 30th of January, when air temperatures were low, show the same subnivian temperature as during the 5th to 7th of March when the air temperatures were considerably higher. Accordingly the tables should not show any correlation between individuals in weekly captures under the snow and air temperatures. Nevertheless, the weeks with the lowest air temperatures also had the lowest catches during the whole period (figure 2). Despite this, one cannot draw conclusions

that there is a direct connection between the modest capture values and the low air temperatures. Since the climatic factors are correlated, correlations between the curves in figure 2 imply nothing but a correlation between capture numbers and weather factors other than air temperature. A more intensive analysis of the different climatic factors (e.g., long periods of cold weather) and their eventual effect on the activity of the subnivian fauna is an area of greatest significance.

During March and April the air temperatures increased considerably, which made the traps begin to melt out. This happened very rapidly in the edge of the wood. Where the snow had melted, other climatic conditions were formed than those which had previously dominated the subnivian space. The animals became exposed to considerably larger temperature variations than previously. This may have influenced the activity of the animals and can explain the strong increase in the trap values.

At the end of the investigation period, larvae of carabid Leistus ferrugineus began to appear. They had been absent from the traps until the week of 11th to 18th of March, after which they were found each week, but only in the edge of the wood. The appearance of Leistus larvae may be considered as a sign of altered climatic conditions. All trapped larvae were full grown which indicates that they were found earlier at the biotopes, but had not shown as much activity until the snow melted away. These observations are in agreement with those that Palm (1962) made when he found plenty of larvae of Leistus ferrugineus on bare patches in the snow cover during March and April of 1962.

The winter activity is followed by the initial spring activity, followed by full spring activity. The collected material was examined up to the 8th of April, when all traps were entirely free of snow.

Results from this investigation, which can be considered a first orientation within a much neglected area and which will be continued in subsequent winters, have made it clear that an important number of invertebrates show subnivian activity. The investigation took place only 10 weeks and was limited to one locality. It is thus likely that the species list would be considerably extended, if the investigation was expanded to include other biotopes.

(SUMMARY (in English) + LITERATURE plus tables and figures)

S u m m a r y: Subnival winter activity in terrest evertebrates.

The results of the investigation have shown, that a considerable number of species show subnival activity. 3338 individuals were taken in the 41 traps during 10 weeks.

The investigation has been performed in three different biotopes. Most of the animals were captured in the field (1722 ind., 16 traps), a somewhat lower number in the edge of the wood (1290 ind., 15 traps) and the lowest number in the forest (328 ind., 10 traps) (Tab. 3).

Many of the captured subnival active animals are earlier known to bee winteractive upon the snow or on bare spots in the snow cower. Examples are: Staphylinidae, Collembola, larvae of Coleoptera (Cantharidae, Staphylinidae and Carabidae) and some spiders. Others are not earlier considered to be winteractive (ex. Lumbricidae and Isopoda) (Tab. 3).

The trap-captures were dominated by Collembola, which represented nearly 2/3 of the total capture. Practically all of the Collembola belonged to three types, of which Isotominae were found in the greatest numbers. Most of them occured in the field. The two other types (Lepidocyrtinae and Tomocerinae) were mainly taken in the edge of the wood (Tab. 3).

The greatest group but one was Coleoptera, where Staphylinidae dominated. Within this family, larvae of *Lathrimaeum atrocephalum* occured in greatest numbers and were chiefly found in the field. Imagines of *Olophrum piceum* were taken exclusively in the edge of the wood (Tab. 3).

The captures showed a marked decrease in numbers of animals in all three biotopes during the fourth week of the investigation (Week D. fig. 2). The same week were also characterized by the lowest minimum temperature during the whole period. As temperature measures has shown the subnival temperatures are high and constant, even when outer temperatures show great differences. Therefore it is scarcely probable that the numbers of animals in the traps directly has been influenced by the outer temperature, in spite of the correlation between the two curves. As the climatic factors are more or less connected with each other, the correlation between the two curves in fig. 2 does not mean anything else than a correlation between trapping-numbers and the common weather. We have to search for an other factor of the weather, which is able to influence the activity below the snow cover. One possible factor is the light, which has ability to pierce the snow.

During the last weeks of the investigation period, when the outer temperatures were higher than earlier, there was an increase in trapping-numbers. On bare spots in the snow cower there appeared new species ex larvae of *Leistus ferruginenus*. On those bare spots, where the favorable subnival conditions have been replaced by a different type of microclimate, caracterized by great temperature amplitudes, the vinter activity have been followed by spring activity.

L i t t e r a t u r

Barber, H S, 1931. Traps for cave inhabiting insects. Journ. Elish. Mitchell. Sci. Soc. 45—46 Chapel Hill.

Coulianos, C C & Johnels, A G, 1962. Note on the subnivean environment of small mammals. Arkiv för Zoologi Ser. 2, Bd 15 nr 24.

Geiger, R, 1950. Das Klima der Bodennahen Luftschicht Braunschweig.

Heydemann, B, 1956. Untersuchungen über die Winteraktivität von Staphyliniden auf Felden. Entomol. Blätter 52.

Heydemann, B, 1956. Die bedeutung der Formalinfallen für Die Zoologische Landesforschung. Faun. Mitt. Norddeutschl. 6.

Kühnelt, W, 1950. Bodenbiologie. Wien.

Palm, T, 1962. Om vinteraktiviteten hos larver av Leistus ferrugineus L. Entomologisk tidskrift årg. 83, hft. 3—4.

Renken, W, 1956. Untersuchungen über winterlager der Insekten. Z. Morph. u. Ökol. Tiere. Bd 45.

Strübing, H, 1958. Schneeinsekten. Die neue Brehm-Bücherei. Heft 220.

Tretzel, E, 1955. Technik und Bedeutung des Fallenfangs für ökologische Untersuchungen. Zool. Anz. 155.

I.

	28-30 Jan.			5-7 March		
	max	min	Ampl	max	min	Ampl
Meteorological temp. at 150 cm high	3.0	-11.8	14.8	9.2	-0.5	9.7
Subnivian temp. under 30-32 cm snow	0.5	0.2	0.3	±0	-0.4	0.4

Table 1: Maxima, minima, and amplitude values of the meteorological and the subnivian temperatures during the two periods of measuring at Furutorp, Lidingö. Temperatures in °C.

	Captures Values per week		
	Max	Min	Mean
Woods	8.8	1.1	3.5
Edge of woods	22.0	3.6	9.6
Fields	17.5	4.9	12.0

Table 2: Maximum and minimum capture of single traps during one week, and the mean capture of all traps/week during the whole period in all three biotopes.

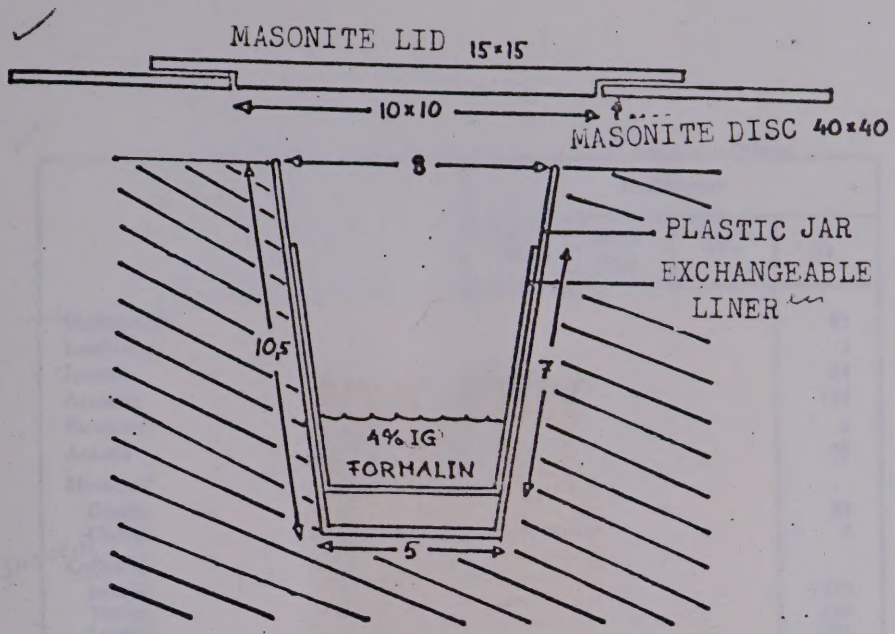

Fig 1. Tvärsnitt av den använda fällan. Alla mått i cm.
Transverse section through the trap. Measures in cm.

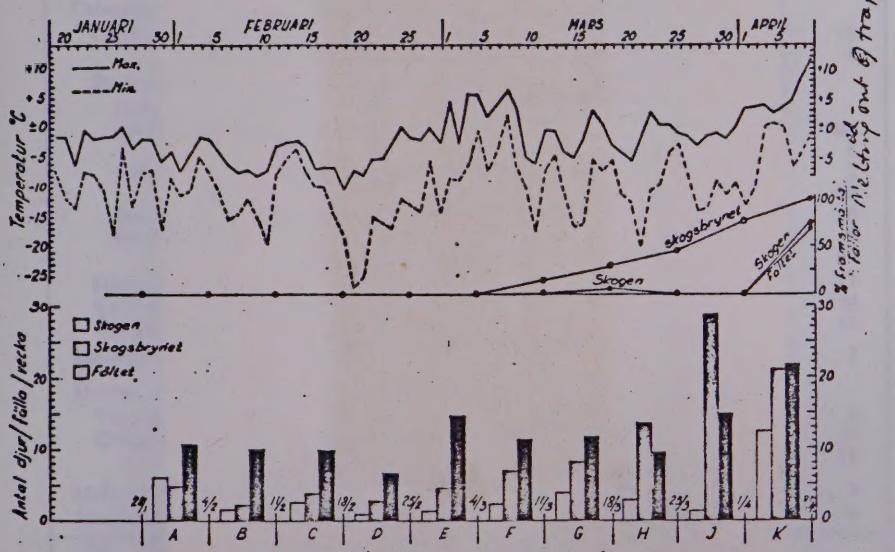

Fig 2. Maximum- och minimumtemperatur (°C) från Röskär, Östra Ryd, under fångstperioden och % framsmälta fällor samt antal fångade djur per fälla och per vecka vid Furutorp, Lidingö 28/1—8/4 1963. Vit stapel = skog, streckad stapel = skogsbryn, svart stapel = fält.

Maximum and minimumtemperatures (°C) Röskär, Östra Ryd, during the investigation period, % uncovered traps and numbers of trapped animals/trap/week at Furutorp, Lidingö 28/1—8/4 1963. White heap = forest, hatched heap = edge of wood, black heap = field.

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	Fällfångster			
	Skog	Skogsbryn	Fält	Sa
Enchytreidae	63	—	—	63
Lumbricidae	1	—	1	2
Isopoda	1	22	1	24
Araneida	18	79	27	124
Pseudoscorpionidae	1	1	—	2
Acarina	22	34	23	79
Myriapoda				
Diplopoda	14	16	7	37
Chilopoda	—	5	—	5
Collembola 2144 individ				
Isotominae	79	475	916	1470
Tomocerinae	28	73	9	110
Lepidocyrtinae	33	186	6	225
Övriga Collembola	10	16	13	39
Homoptera				
Cicadina	—	39	29	68
Aphidina	—	—	3	3
Hymenoptera				
Formicidae	—	2	—	2
Övriga Hymenoptera	—	2	—	2
Coleoptera 1042 individ				
Carabidae larver	3	9	1	13
„ imagines	—	1	—	1
Staphylinidae				
Lathrimaeum athocephalum larver	19	110	658	787
„ imagines	—	1	—	1
Olophrum piceum larver	—	2	—	2
„ imagines	—	87	1	88
Stenus clavicornis imagines	—	10	—	10
Övriga Staphylinidae larver	—	5	1	6
„ „ imagines	7	23	4	34
Silphidae larver	6	5	—	11
Cantharidae larver	12	60	6	78
Övriga Coleoptera larver + imagines	1	9	1	11
Lepidoptera larver	—	1	1	2
Diptera				
Tipulidae imagines	1	1	—	2
Övriga Diptera larver	8	6	7	21
„ „ imagines	—	9	3	12
Mollusca	—	1	1	2
Icke bestämda	1	—	3	4
S:a	328	1290	1722	3338

Tabell 3. Totala antalet fångade djur i de olika biotoperna uppställda i systematisk ordning.
Total number trapped animals/biotop systematically arranged.

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